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IN THE PAST TEN YEARS

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PHYSICAL RESEARCH IN COMMUNIST CHINA  
IN THE PAST TEN YEARS

[Following is a translation of an article written by the physicists Wang Zhu-xi, Wang Shou-wu, Wu Yiu-hsuen, Shi Ru-wei, Ma Da-you, Huang-Kun, Chien Lin-zhao and Zhang Zhi-san, appearing in K'u-hsueh T'ung-pao (Journal of Science), Peiping, Vol. 18, 1959, pages 568-571.]

Physics is the basis of all branches of scientific technology. In this century, the rapid development of physics has not only expedited the development of other sciences, but has also helped develop new production techniques which greatly improve the living of all people. But in old China, due to the corruption of the government, production power lagged far behind. It was not until some thirty years ago that we began our study of physics. During that period there were only a handful of researchers and the facilities were insufficient; hence the research work was very limited. Within a period of several years, only a weak foundation was established in theoretical physics, in the X-ray spectrum, and in the field of radiative elements. Moreover, during the war against Japan, even the established weak foundation crumbled into pieces. After the People's Republic of China was founded, under the correct leadership of the Communist party, a series of important measures in the development of physics were taken to strengthen the physics courses in universities and advanced institutes, and to establish research centers for specialization to meet the need of national construction. These measures effectively guarantee the education of workers in physics. In several years, the number of physics graduates has rapidly increased to about five times the number of physics graduates before liberation. As far as research institutes are concerned, the Atomic Energy Research Institute and the Physics Research Institute

were established by the Academia Sinica. Under the production department, research centers and laboratories related to physics have been established. For further promotion of the development of research in China and for better coordination with the production task of the nation, a general future plan of scientific technology was adopted in 1956. Such a plan has given momentum to the development of physics in China. The education of Marxism by the party for all scientific workers, including physics workers, enabled the scientific workers to realize that the purpose of scientific research is the construction of socialism. The level of understanding of this basic principle was particularly raised after the rectification movement in 1957. This series of measures has created favorable conditions for the rapid development of physics in China.

The agricultural and industrial great leap forward in 1958 added new momentum to the development of physics in China. Since then, research in physics and the task of national construction have been more closely connected. Several new research centers were established and the scope of new research was widened. The scientific workers especially, particularly the young scientific workers, have exerted their greatest energy in answering the call of the liberation ideology of the party, actively developing their work, increasing their confidence, and bringing to scientific research a new appearance.

A brief description of the development of physics researches in China in the last decade is given in the following:

1. Theoretical physics: Before liberation, research in theoretical physics had a certain foundation, but most of the research was done in foreign countries. After liberation, new development in theoretical physics began. In the past decade emphasis has put on research in the theory of elementary particles, nuclear physics, solid state theories, and statistical physics.

Recently quantum field physics has become the main interest of study related to the physical properties of elementary particles. In the period from 1949 to 1956, our main work was confined the mathematics of this subject. It included the extension of the wave equation of Weiss's theory to an equation that determines the wave function of the space-curve surface varying with respect to the change of the curve surface. In the research on nonlocalized fields, we have compared the two quantum

fields of higher order derivatives. At the end of 1956, some of the field-theory workers participated in the work of the Joint Nuclear Research Institute. With the assistance of the Soviet field theory workers, the theoretical and experimental researches were closely combined. For example, we have studied the method of utilizing the collision of a nucleus and a meson or heavy particles to determine the spin and relative phase space of strange particles. Moreover, we have also studied the angular distribution caused by collision, the end-product of polarized particles after collision, and the rules for choosing conditions of polarization. Also, we have discussed the indeterminateness of magnetic south relative to phase-space analysis, the effect of "Chao Tze" [epithermal neutron] and "Fan Chao Tze" [anti-epithermal neutron] upon the decay of the meson, and problems concerning the inter-relationship of experiments. The rectification movement of 1957 and the great leap forward of 1958 provided new strength for field theory work. The development was characterized by the close relationship between theory and experiment as well as the rise in standards of both quality and quantity. During this period, the emphasis of our work was on the systematic study of the capture phenomenon and the decay of elementary particles, the calculation of lifetimes; and the several forms of decay of the K meson and epithermal neutron. The above experiments verified the mathematics well. Further, we studied, under the condition of nonconstant phase space, the phenomenon of particle decay for half-integer spins, the phenomenon of angular distribution of particles when one spin is zero and the other is  $\frac{1}{2}$ , and the problem of  $\mu$  meson-capture by proton radiation.

Concerning nuclear theory, our theoretical physicists carried out a series of studies on the "Wei Siang" [mirror image] theory of nuclear force with the aim of investigating whether the potential of two bodies, satisfying the experimental results of scattering, can accurately produce the binding energy of the hydrogen nucleus. Recently we have applied the wave function, using the two-body forces -- the central force and tensor force -- to calculate the binding energy of  $\text{He}^4$ , and the result is equivalent to 93.3 percent of the experiments. Concerning nuclear structure, work has been done on statistical theory, the shell model and synthetic models. With the use of the statistical

shell model and synthetic models. With the method to study nuclear distribution and its relationship with the shell model, a set of imaginary numbers of the shell structure was obtained. Moreover, the density of nuclear distribution was obtained, and the result conformed to experiments. During the leap forward of 1958, further analysis was made in relating the "Bu-luk-na" theory to shell models. The result suggested that the result of the frequent interaction between the nucleon outside the completed shell and the nucleon inside the completed shell was equivalent to the polarity of the nuclear substance surrounding the nucleon. The analysis of the energy spectrum of the nuclear neighborhood of  $\text{Pb}^{208}$  indicated that the intensity of the interaction between two free nucleons. On the basis of this fact we calculated the energy level of the inverted double-layer state, and the result was similar to experimental results. Analysis of the binding energy of multiple layers based on shell models, and analysis of part of the low excitation-potential spectrum on the basis of partial experience, yielded results most of which conformed to data obtained from experiments on binding energy.

We have also made a series of studies of solid-state theory. It was proved that every small block of any Brillouin zone can be combined into a first zone without any crack. Concerning the theory of polarization, research was done on the interaction between electron and phonon for the parameter  $\alpha < 6$  and  $\alpha > 6$ . On this basis we began to understand a unified theory. By using the heat-insulation approximation method to study the self-trapping state of the "Be ka" type, we found that the possibility of a self-trapping state of static deformation in atomic semiconductors was very limited. Concerning semiconductors in the study of applied electronics, we discussed the conditions under which the greatest voltage could be generated when electrons produced voltage, and we also discussed the efficiency of injection of minority carriers through p-n junction alloys. Other work on solid-state theory is related to internal friction. On the basis of the linearity of irreversible thermion, we established a general theory of linear internal friction. We investigated further the internal friction theory of metals in both ordered and disordered states. Research was also done on the internal friction theory of carbon atoms in face-centered alloys.



Statistical physics has also been under development. We have established the method for calculating the free energy of the binary solid solution configuration and the expansion of the temperature reciprocal of the free energy of the face-centered cubic solid solution.

We also investigated the theory of "yung bien" [variable] viscosity in the study of fluids.

2. Solid-state physics: In the past decade considerable progress has been achieved in many important areas of solid-state physics.

Semiconductor physics is a new branch of scientific research. After liberation the party and the government greatly emphasized its development. Not long after the founding of new China, several semiconductor plants were built and the foundations of semiconductor research were established simultaneously at various scientific research institutes. During the first period, we concentrated on rectifiers and photosensitive resistors. In 1956, we started to purify germanium, trying zone purification and the production of single crystals. Finally we could produce single germanium crystals. Later we used material produced in China for manufacturing semiconductor items such as intermediate-frequency triodes, germanium point-contact diodes, and germanium bond diodes.

The production of semiconductor parts promoted research in semiconductor electronics. At the end of 1957, techniques of measuring various characteristics of semiconductors were established. We also investigated the effect of surface combination velocity upon the distribution of the germanium photoconductivity spectrum. On this basis we established the technique of determining surface combination velocity. During the great leap forward of 1958, many research units in the country began to purify germanium and silicon, thus making possible the experimental production of various semiconductor tubes on a large scale. Quality of the products was improved and the cut off frequency was raised from several megacycles to several hundred megacycles. Concerning the production of semiconductor photo-# and heat-sensitive electronic parts, many production units in the nation have been trying out the production of various types of photosensitive and heat-sensitive resistors. Some of them are in large-scale production. Some units have experimentally manufactured semiconductor-thermo-couple electric generators with capacities from

two to ten watts. The production of semiconductor electronic parts helps expedite the development of new techniques in China.

Regarding metallic physics, workers in physics in China are greatly interested in internal friction problems within metals and alloys. We have done much research on problems of diffusion and precipitation of carbon and nitrogen atoms in steel, and have determined the internal friction peak caused by the precipitation process. On this basis we tried to explain the cause of "lan" [refined] brittleness and tempering brittleness of steel. In the research on internal friction, our scientists have different viewpoints as to the structure of internal friction caused by carbon diffusion in "Aus" body steel and in face-centered cubic nickel. Doubtless further discussion of this problem may help explain the cause of the small diffusion of carbon atoms, alloy elements and "Kung Wei" [space gaps] in crystal with closely spaced atoms; the solution of this problem may help explain the transformation of the "Aus" body during the heat treatment of steel and iron. Concerning the problem of change of phase of alloys, we have investigated the effect of decomposition of the "Aus" body in boron steel upon the nuclear formation and the growth of "Chu Kwang Ti" [luminous bead body]. We have also studied the relationship between the type of carbide and the percentage composition of alloy during the initial formation stage of the "Chu Kwang Ti" in chromium steel. Systematic researches were made in techniques for removing the residue of the "AUS" body after the quenching and fire treatment of high-speed steel. Regarding general deformation, we have investigated problems for single aluminum crystals. Moreover, we did some work in metal structures. Since the great leap forward, we have obtained best results in the study of crystal orientation of silicon steel plates. We are able to produce in laboratories silicon-steel plates with 90% orientated crystals and cubic-structure silicon-steel plates with a high degree of crystal orientation, a recent international achievement. Researches on materials needed for new technology such as high-temperature alloys, metallic china and metallic "Tu Tseng" [point] have been considered primarily important. Recently, for the iron-tungsten-silicon system, the scientific workers set up the parallel phase diagrams and investigated heat resistance, oxidation, protective method, alloy element diffusion, creep, and grind re-

sistance. In approaching these problems collective manpower was applied. The result proved fruitful.

In connection with the study of magnetism, after liberation we studied the heat treatment of silicon steel plates and the relationship between heat treatment and the alloy properties of aluminum, nickel and cobalt. We also measured, at different temperature, the magnetism of alloys belonging to the iron, nickel and aluminum group. The success in this enabled us to understand the causes of coercivity and the structure of alloys at different stages of precipitation. Moreover, our specialists in magnetism investigated the structure and magnetism of various "Po Mo" [interstitial] alloys produced in China. The temperature at which the cubic structure of "Po Mo" alloy contains 50 percent nickel was determined. We have been producing ferrite for making high-frequency magnetic core and microwave spare parts. We have improved in different degrees the qualities of various products. In connection with the theory of magnetism, we used the wave functions to calculate the rate of diamagnetism of atoms or ions with 2 S and 2 P electrons, to discuss the approximation solutions of spin wave theory, and to explain the antisymmetric state of the peak of the domain boundary displacement resonance.

Regarding the study of light emission of solid bodies, after liberation we started research in field emission of light, putting main emphasis on light-emitting materials in neon tubes and phosphorescent materials are sensitive to infra-red. But rapid development of this field began only last year. This year the research in photo-emission has been extended to research in long-range light emission, electrode light emission and field emission of light. At present there exist almost one hundred units doing research on and producing the above-mentioned materials. The highest efficiency obtained with field light-emission products is 17-lumens/watt. Some sample products of long-range light-emission materials maintain a  $2 \times 10^{-4}$  "A-poster-bu" [name of scientist] light standard after emitting light for 13 hours. We also analyzed the heat-light emission curve.

The development of X-ray crystal analysis has become popular in the past decade. X-ray crystal analysis laboratories have been established in physics, chemistry, mineral, and silicate research organs and universities. Work in this field during the last few years



can be divided into three types. The first type is related to phase analysis. The objects of analysis include minerals, industrial products and by-products of chemical reactions. The second type is related to the investigation of phase changes of metals, alloys, and nonmetals and chemical equilibrium. The third type is related to the structural measurement of unknown crystals. It includes research on the structural change of the phase of crystals of the aluminium, copper and nickel family. These researches reveal a different concept of structural changes in the single-phase area of alloys, and they also supply satisfactory explanations of these structural changes. Analysis of the crystal structure of tetraphosphoric trisulfide, 2 selenic acid 3 hydrogen sodium "Pu Tao Shih" was made.

Since the great leap forward last year, we have been able to handle the technique to produce various crystals. Under the piezoelectric quartz category, we can produce sodium potassium tartrate, ammonium biphosphate, potassium tartrate and diamino ethylene tartrate. Ruby is produced on a large scale. The cultivation of paramagnetic single crystals has been successful. Single crystals for optics, such as alkali metal halides and their compound crystals, have been produced. We have also produced some scintillating crystals. All these achievements have established the foundation of crystal research in China.

Regarding low-temperature physics, we have established the liquid air and liquid hydrogen systems during the past few years. Since the great leap forward, we have established the liquid helium system and are able to produce liquid helium. The ability to handle all these techniques provides highly favorable conditions for the establishment of low-temperature physics in China.

High-pressure physics research was started last year. We have installed facilities for work at 30,000 atmospheres although the work has just been started.

3. Spectroscopy: After liberation, the use of spectroscopy in China become popular. The development of emission spectrum analysis has been especially rapid. Now emission spectrum analysis is a popular tool applied in the steel industry, the nonferrous industry, the machine production industry, and the geology and petroleum industry. For analyzing minerals, a practical semi-quantitative analysis system has been established. The technique to determine the "Da How [literal translation: large number] elements of the earth's surface

quantitatively has been developed, hence greatly increasing the efficiency of analysis. We also utilize the light intensity of flame to analyze excitable elements. The conditions under which we determine the small quantity of metals in minerals have been investigated and the standard of the analysis technique has been raised. Regarding the analysis of steel and nonferrous metals, we investigated the effects of grain structure and coexisting elements by spectrum analysis and we also studied the method for analyzing new products to increase the sensitivity of analysis. The result of researches suggested an effective method to eliminate the undesirable effects under certain conditions.

Experimental production of photoelectric instruments and research on excited light sources have been carried out in the last few years. Improvement has been made in originally produced light sources to satisfy certain work requirements. Experiments were made to produce a new type of light source. Our initial success is the production of multiple-capacity excited light sources and double electric-arc light sources. In the investigation of the excitation of light sources and the evaporation problem, we have recently measured the space distribution of various basic parameters of equivalent-ion areas of the d. c. electric arc. Also, we have used the CN band to measure the temperature of the carbon arc. In the study of the existence of self-absorption and the relationship between the spectral intensity and the density of matter, we proved the linear relationship between the slope of the calibration curve and the logarithmic value of the density of matter. On the basis of this we derived the parabolic equation which is an approximation of the relationship between the spectral intensity and the density of matter. Regarding the experimental production of photoelectric recording instruments, we have made the integral doublet condenser installed in the ISP-51 spectrograph and the fixed photo-electric set installed in the medium size spectrograph.

Work on the molecular spectrum has been in progress in recent years. Regarding the molecular vibration spectrum, we have investigated the functional relationship between the intensity of the combined scattering spectrum and the excitation causes and the arrangement of instruments. On the basis of this, we can use the spectrum analysis method in low-boiling-point petroleum distillation processes. Later we extended the scope of

boiling-point distillation analysis. In studying the polarization of the combined scattering spectrum of Rochelle salt, we proved that the so-called "short" hydrogen bond did not exist in this type of piezo electric quartz. The most rapid development in vibration spectra is the infra-red absorption spectrum. Since 1958, over ten infra-red absorption spectrum laboratories have been established. In the analysis of hydrocarbons, we have established spectrum-comparison methods for analysis of single elements and groups of elements. By utilizing the absolute intensity of absorption, we carried out numerical calculation of several simple systems such as  $\text{CH}_2$  and  $\text{CH}_3$ . The result conforms well to the actual situation. At the initial stage, we have obtained significant results in structural analysis and quantitative analysis of material of "Kao Fen Tsi" [high molecule or weight].

Chemists and bio-chemists in recent years have generally adopted the molecular electro-spectrum to investigate the structure of various organic substances and some theoretical problems such as the structure of "Dien Fen Tuan" [starch lump] and its iodine compound. The position of the spectrum as calculated from theory approximates well the result of actual observations. When working on the electron transfer spectrum of aromatic substances and oxides, we measured the ionization potential of various compounds. We have analyzed more than fifty inorganic elements by color comparison methods and the methods are being improved in different degrees. In the analysis of rare-earth elements, besides attaining success in analyzing various kinds of rare-earth elements, we also investigated the effects of molecular extinction coefficients upon the parameters of the instruments. This may enable us to simplify the process of analysis.

Research on the microwave spectrum has just begun in China.

4. Electronics: After several years of hard work, we have established certain foundations in this field. We have started research in both the theory and techniques of microwaves. Now the standard of theory and technique in microwaves has been raised. We are able to produce many electronic parts and microwave facilities.

Researches in radio broadcasting are highly important in both theory and practice. We have establish-

ed reasonably distributed stations for observation of the ionosphere. This not only enables us to carry out the vertical measurement of the ionosphere at its effective altitude, but also it furnishes the basis for inferring the frequency of shortwave radio communication and satisfies the general research requirements. Regarding the theoretical aspects of the ionosphere, we investigated the disturbance of the ionosphere, the propagation problem of forward scattering in the ionosphere and troposphere, and the deduction of the field intensity equation of the penumbra region. Before liberation, antenna work was considered very important. Since liberation our antenna development has been very rapid.

Regarding electronic circuits, research has put great emphasis on the production of various kinds of required electronic instruments for, e.g., electrophysiological research and atomic research. Since automatic plate-amplitude modulation used in radio transmitters has proved effective in saving power at sound frequencies, it has been generally used for medium-wave broadcasting. The corresponding theories have also been well developed. Because of the urgent needs in atomic energy, electronic computers, multiple-channel communication and other technical and scientific requirements, pulsation technique has developed rapidly. We have succeeded devising in trigger scanning circuits suitable for atomic research and a linear very slow scanning circuit which generates a voltage wave. We are also doing research on rapid pulse techniques. Since 1956, research on crystal tube circuits has been developing rapidly. On the one hand we have established experimental facilities for crystal tubes and on the other, we have been designing circuits and doing theoretical analysis.

As to the manufacturing of electronic parts, we have successfully manufactured many types of ultra high-frequency tubes and other kinds of electronic items in recent years. Some theoretical problems have been studied.

Cathode theories have been under development in recent years. Research on cathodes has been carried out. We suggested the use of a simple cathode made of compressed barium and tungsten. It is comparable to any other foreign products in transmission, evaporation, poisoning, secondary transmission coefficient, and lifetime.

Regarding electro-optics, we have done work on the theory of "Hsiang Cha" [image difference], including a study of the effect of the distribution of the initial velocity of electrons upon the image quality related to the electron-emission-optical system. It also includes the study of the double symmetric electron lense, and the "Hsiang Cha" theory of symmetric electro-optics rotation when electric charge exists in space. Works already completed in laboratories include a new method to extract electron bundles from the betatron and the design of an automatic scanning instrument for electron locus. In 1958 we manufactured our first electron microscope.

5. Sound: Several years ago we started research in sound. The development has been evident especially since the great leap forward in 1958. The most rapid development has been the application of supersonic techniques. We have produced various kinds of supersonic instruments such as a field geological detection instrument and the "Chia Kung Chi" [work machine]. Their applications have been urged. In the same period, we carried out research on the theories of sound wave propagation and supersonic wave propagation. The determinations of the absorption of audible frequencies in air and the effect of temperature upon it were included in this research. We also worked on problems of sound absorption in liquids and its velocity in liquids. We have been successful in using strong sound to produce an emulsoid collecting substance for "Fu Suan" [floatation selected] minerals.

We also studied noise control. Our scientists surveyed the noise distribution of several factories and made a frequency spectrum analysis. From this we may develop methods to eliminate noise. Also, we did research on sound frequency reduction materials, sound insulation structures and sound absorption structures.

For solving the acoustic problems of big building, in 1958 our scientists carried out surveys on sound qualities of building, sound effects of performers, noise, and echoes, and established a sound quality index and an index for electro-acoustical systems. Experimental model techniques have been established, such that with a model 1/40 the size of the actual structure we can carry out a series of surveys. By using the geometric techniques to study sound, we theoretically analyzed the distribution and changing conditions of sound. By



comparison with actual situations, we found the results can be reliably applied.

To further electro-acoustics, the electro-acoustic instrument industry is being established. We can produce high-quality loud speakers, high-quality condensers and dynamic microphones.

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In a word, compared with the incomplete and weak foundation of the work in physics before liberation our new development of the past decade is highly significant. We have educated a great number of physics staffs. Here we must mention the reason we have been able to achieve such obvious success in physics in such a short period. The Soviet Union and other brother countries have given us valuable assistance. However, some areas of physics and some boundary scientific fields, have not yet been explored in our country and are to be established. The application of the methods of physics to research in other sciences should be further emphasized. The existing foundations should be further extended and improved. Special attention must be given to the rapid expansion of scientific fields important to national construction and significant to scientific development. We believe that in the near future physical research in China can march forward together with that in all the progressive countries of the world, and will be able to contribute more to our national construction.